

# FLAT PANEL DISPLAY WITH REPELLANT AND BORDER AREAS AND METHOD OF MANUFACTURING THE SAME

## CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of European Patent Application No. 05104823.9, filed on Jun. 2, 2005, and Korean Patent Application No. 10-2005-0116982, filed on Dec. 2, 2005, which are hereby incorporated by reference for all purposes as if fully set forth herein.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a flat panel display and a method of manufacturing the same, and more particularly, to a flat panel display suitable for patterning performed by inkjet printing and a method of manufacturing the flat panel display.

### 2. Discussion of the Background

An organic layer with a light-emission layer can be formed as a component of a flat panel display by inkjet printing. In an inkjet printing process, an active material is first dissolved in a solvent to form ink. The ink is then jetted as droplets on an active area of a substrate by a printing process such as piezo printing or bubble-jet printing. Mechanical arrangement can be used to position an ink head corresponding to the desired position of the droplets on the substrate. After the solvent dries, the ink-jetted active material forms a film on the active area.

One main failure of the inkjet printing technique is the overflow of ink droplets into adjacent active areas, which can lead to color mixing.

The inkjet printing technique can be used to manufacture a full-color display with light-emitting polymers (LEPs).

United States Patent Application Publication Number US 2002/0004126 A1 discloses a process in which small drops of an active material, such as a hole-transporting or light-emitting material, are deposited on an active area of a substrate. An active area defines the pixel area, and the dimension of an active area designed for use in high-resolution displays for mobile applications can be in the range of 30  $\mu\text{m}$  by 180  $\mu\text{m}$ . Advanced commercially available inkjet heads are able to generate drops with diameters of about 30  $\mu\text{m}$  or greater. Thus, use of ink drops with this diameter in a high-resolution display may result in ink overflow into neighboring pixels. To prevent this overflow, the substrate surface could be modified.

There are two approaches to modify the substrate surface: one approach is to create a substrate surface with different wetting properties for ink in the active area and outside the active area; the second approach is to form geometrical barriers on the substrate surface to mechanically prevent overflow of the ink outside an active area.

The first fundamental approach of creating a substrate surface with different wetting properties for ink in the active area and outside the active area is disclosed in EP 0989778 A1. The wetting property disclosed in this reference is the surface energy across the substrate. A contrast in surface energy across the substrate is produced by an appropriate selection of materials that form the substrate surface. Print-applied ink can only flow in areas having high surface energy, whereas areas having low surface energy serve as barriers to prevent flow of ink. To obtain a film of inkjetted active material with a homogeneous thickness, a surface with low surface energy can be positioned beyond the boundary of a pixel surface of an organic light emitting diode (OLED). The coating thickness

of the film may be homogeneous inside the active area up to the boundary, but then noticeably decline outside an active area around the barriers.

Variation in contrast of the surface energy across the substrate can be achieved in different ways and with different methods.

EP 0989778 A1 discloses two coating structures on a substrate. With a common surface treatment using plasma, an upper coating can be provided with low surface energy, while a lower coating can be provided with high surface energy. The lower coating can be typically formed of an inorganic material, such as silicon oxide or silicon nitride.

Thus, the upper organic coating and lower inorganic coating act as a boundary zone, where the upper coating has low surface energy to repel the ink. Hence, this structure facilitates the deposition of polymer films by inkjet printing.

However, the deposition and structuring of this coating requires processes that are typically used in the semiconductor industry, such as coating separation, sputtering, and gas phase processes including plasma enhanced chemical vapor deposition (PECVD). These processes can be expensive and accordingly can reduce the cost advantage gained by the use of OLED technology. Moreover, the upper coating can form a surface topography since areas with low surface energy have a defined height above the substrate surface. As a result of this height, the polymer film may be formed to an undesirable thickness.

JP 09-203803 AA discloses a chemical treatment of a substrate surface that has been previously treated with photoresist. The photoresist is then exposed to light through a mask and developed. In such a structure, the areas with the photoresist have low surface energy, while areas without photoresist have high surface energy. The flanks of the photoresist structure possess a mean surface energy and thus provide a gradual transition of the surface energy across the flanks. However, the flanks of the photoresist structure do not constitute a defined boundary zone with selectable surface energy and geometry, and have low spatial dissolution capacity.

JP 09-230129 AA discloses a two-stage surface treatment method including treating selected regions of an entire substrate possessing low surface energy with short-wave light (e.g., UV light). The short-wave light increases the surface energy of the selected regions. However, the resulting contrast of the surface energy is limited, and the time-consuming exposure process may not be suitable for mass production.

DE 10236404 A1 discloses surface fluorination of photoresist using  $\text{CF}_4$ , also including a plasma process combined with a liftoff process, for patterning. However, this process requires chemical vapor deposition (CVD), which adds considerable process costs and time. Furthermore, the surface energy changed by surface modification can be unstable over time. This is because fluorinated parts of the photoresist layer may diffuse into the photoresist bulk to maintain equilibrium. Additionally, the fluorinated parts may not chemically adhere to the photoresist bulk and may be washed away after exposure to an acid-containing solution, such as PDOT:PSS, which is commonly used for polymer OLED manufacturing.

DE 10343351 A1 discloses the deposition of a hydrophobic layer, such as the product sold under the trademark Teflon®, which repels ink. Teflon® can be deposited by CVD and patterned by liftoff technologies, laser ablation, or by a shadow mask. However, this technology also requires CVD or thermal evaporation, which both are vacuum-based technologies and require considerable expenses and process time.

U.S. Pat. No. 6,656,611 B2 discloses the use of a polysiloxane-based photoresist to form insulating areas and define active areas of a display. To generate a passive matrix display,